

Supercritical Pulverized Bituminous Coal Plant

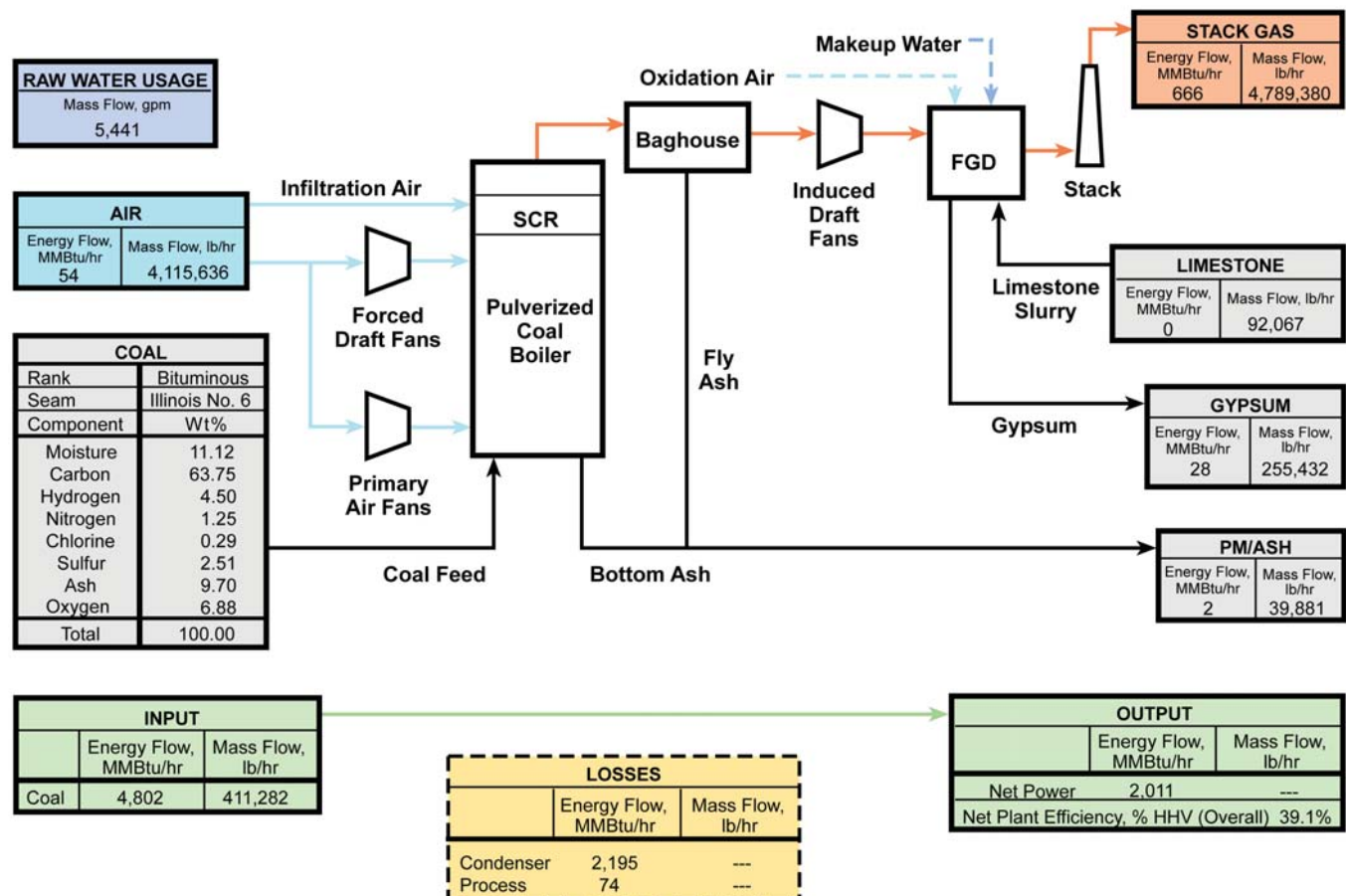
Plant Overview

This analysis is based on a 550 MWe (net power output) supercritical bituminous pulverized coal (PC) plant located at a greenfield site in the midwestern United States. This plant is designed to meet Best Available Control Technology (BACT) emission limits. The plant is a single-train design. The combination process, heat and mass balance diagram for the supercritical PC plant case is shown in Figure 1. The primary fuel is an Illinois No. 6 bituminous coal with a higher heating value (HHV) of 11,666 Btu/lb. The capacity factor (CF) for the plant is 85 percent without sparing of major train components. A summary of plant performance data for the supercritical PC plant is presented in Table 1.

Table 1. Plant Performance Summary

Plant Type	PC Supercritical
Carbon capture	No
Net power output (kWe)	550,150
Net plant HHV efficiency (%)	39.1
Primary fuel (type)	Illinois No. 6 coal
Levelized cost-of-electricity (mills/kWh) @ 85% capacity factor	63.3
Total plant cost (\$ × 1,000)	\$866,391

Figure 1. Process Flow Diagram
Supercritical Pulverized Coal Unit



Note: Diagram is provided for general reference of major flows only. For complete flow information, please refer to the final report.

Technical Description

The analysis for the supercritical PC plant is based on a commercially available supercritical dry-bottom, wall-fired boiler equipped with low-nitrogen oxides burners (LNBs) with over-fire air (OFA) and selective catalytic reduction (SCR). The unit is a balanced-draft, natural-circulation design equipped with a superheater, reheater, economizer, and air preheater. Hot flue gas exiting the boiler is treated by an SCR unit for nitrogen oxides (NO_x) removal, a baghouse for particulate matter (PM) removal, and a wet limestone forced oxidation scrubber for sulfur dioxide (SO₂) control and co-removal of mercury (Hg). This plant utilizes a conventional steam turbine for power generation. The Rankine cycle is based on a single reheat system with steam conditions of 24.1 MPa/ 593°C/593°C (3,500 psig/1,100°F/1,100°F).

Achieving a nominal 550 MWe net output with this plant configuration results in a HHV thermal input requirement of 1,406,161 KWt (4,799 MMBtu/hr basis). This thermal input is achieved by burning coal at a rate of 411,282 lb/hr, which yields an HHV net plant heat rate of 8,721 Btu/kWh (net plant HHV efficiency of 39.1 percent). The gross power output of 580 MWe is produced from the steam turbine generator. With an auxiliary power requirement of 30 MWe, the net plant output is 550 MWe.

Environmental Performance

This study assumes the use of BACT to meet the emission requirements of the 2006 New Source Performance Standards.

The supercritical PC plant has an emission control strategy consisting of LNBs with OFA and SCR for NO_x control, a pulse jet fabric filter for PM control, and a wet-limestone, forced-oxidation scrubber for SO₂ control. After NO_x emissions are initially controlled through the use of LNBs and OFA, an SCR unit is used to further reduce the NO_x concentration by 86 percent. Particulate emissions are controlled using a pulse jet fabric filter, which operates at an efficiency of 99.8 percent. The wet-limestone, forced-oxidation scrubber for SO₂ control achieves 98 percent removal efficiency. The byproduct, calcium sulfate, is dewatered and stored onsite. The wallboard-grade material can potentially be marketed and sold but, since it is highly dependent on local market conditions, no byproduct credit is taken. The combination of SCR, a fabric filter and wet scrubber also provides co-benefit Hg capture at an assumed 90 percent of the inlet value.

A summary of the resulting air emissions is presented in Table 2.

Cost Estimation

Plant size, primary/secondary fuel type, construction time, total plant cost (TPC) basis year, plant CF, plant heat rate, fuel cost, plant book life, and plant in-service date are used to develop capital cost, production cost, and levelized cost-of-electricity (LCOE) estimates. Costs for the plant are based on adjusted vendor-furnished and actual cost data from recent design/build projects. Values for financial assumptions and a cost summary are shown in Table 3.

**Table 2. Air Emissions Summary
@ 85% Capacity Factor**

Pollutant	PC Supercritical Without CCS
CO₂	
• tons/year	3,632,123
• lb/MMBtu	203
• cost of CO ₂ avoided (\$/ton)	N/A
SO₂	
• tons/year	1,514
• lb/MMBtu	0.085
NO_x	
• tons/year	1,250
• lb/MMBtu	0.070
PM (filterable)	
• tons/year	232
• lb/MMBtu	0.013
Hg	
• tons/year	0.020
• lb/TBtu	1.14

Project contingencies were added to each case to cover project uncertainty and the cost of any additional equipment that could result from detailed design. The project contingencies represent costs that are expected to occur. Project contingency was 10.7 percent for the supercritical PC case TPC. No process contingency is included in this case because all elements of the technology are commercially proven.

This study assumes that each new plant would be dispatched any time it is available and would be capable of generating maximum capacity when online. Therefore, CF is assumed to equal availability and is 85 percent for PC cases.

The 550 MWe supercritical PC plant is projected to have a TPC of \$1,574/kWe, resulting in a 20-year LCOE of 63.3 mills/kWh.

Table 3. Major Financial Assumptions and Resulting Cost Summary¹

Major Assumptions			
Case:	1x550 MWe net Supercritical PC		
Plant Size:	550.2 (MWe, net)	Heat Rate:	8,721 (Btu/kWh)
Primary/Secondary Fuel (type):	Illinois #6 Coal	Fuel Cost:	1.80 (\$/MMBtu)
Construction Duration:	3 (years)	Plant Life:	30 (years)
Total Plant Cost ² Year:	2007 (January)	Plant in Service:	2010 (January)
Capacity Factor:	85 (%)	Capital Charge Factor:	16.4 (%)
Resulting Capital Investment (Levelized 2007 dollars)			Mills/kWh
Total Plant Cost			34.7
Resulting Operating Costs (Levelized 2007 dollars)³			Mills/kWh
Fixed Operating Cost			3.9
Variable Operating Cost			5.7
Resulting Fuel Cost (Levelized 2007 dollars) @ \$1.80 / MMBtu			Mills/kWh
			19.0
Total Levelized Busbar Cost of Power (2007 dollars)			Mills/kWh
			63.3

¹Costs shown can vary \pm 30%.

²Total plant cost includes all equipment (complete with initial chemical and catalyst loadings), materials, labor (direct and indirect), engineering and construction management, and contingencies (process and project). Owner's costs are not included.

³No credit taken for by-product sales.

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Reference: Cost and Performance Baseline for Fossil Energy Plants, Vol. I, DOE/NETL-2007/1281, May 2007.

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